RADY 401 Case Presentation: Pneumoperitoneum

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2022
Focused patient history and workup

• Brief History: 4 month old, ex-34 week female with a history of laryngomalacia, feeding difficulty, and G-tube dependence. Discharged from the NICU ~3 weeks ago after several months of respiratory and feeding support due to RDS. Occasionally requires supplemental O2 at home mostly a night or traveling in the car.

• HPI: One day of worsening irritability, abdominal distension, and respiratory distress. Requiring more O2 at home than usual and vomiting more than her baseline. One day of fever prior to presentation in the context of routine vaccination at PCP. Progressively became inconsolable over the course of the day.

• Pertinent PE:
  • General: Toxic appearing, minimally responsive, diffuse mottling
  • Pulmonary: grunting, tachypneic
  • Abdominal: Distended, firm, cyanotic
  • Vascular: >5 second capillary refill, cool extremities, palpable central pulses

• Vitals: BP 78/61 | Pulse 190 | Resp30 | Temp 36.6 | SpO2 99% on FiO2 50%

• Work Up: Chest x-ray, Abdominal X-ray
  • PICU called to assist in stabilization

Reference: 9
What is in our differential diagnosis?

Broad differential for the **inconsolable** infant involving nearly every organ system:

- **Skin**: hair tourniquet syndrome, diaper dermatitis, atopic dermatitis, cellulitis
- **Eyes, Ears, Throat**: corneal abrasion, glaucoma, otitis media, teething, stomatitis
- **Cardiovascular**: PSVT (most frequent form of symptomatic arrhythmia), myocarditis
- **GI**: Acute abdomen (appendicitis, obstruction, malrotation with volvulus, perforation, NEC), GERD, hernia
- **GU**: UTI, ovarian/testicular torsion
- **Neuro**: meningitis, encephalitis, head trauma, increased ICP
- **MSK**: bone fractures, septic arthritis, osteomyelitis

*Peds Top Tips: Sudden onset bilious emesis in a previously healthy neonate (most commonly <1 month old) is volvulus until proven otherwise and is a surgical emergency.*

References: 8, 9
What is in our differential diagnosis?

Let’s focus our differential considering our patient’s age, medical history, physical exam, and labs:

• 4 month old, premature infant
• Respiratory failure
• Firm, distended, and cyanotic abdomen, diffuse mottling
• Lactic acidosis

• **Respiratory:** Pneumonia, pneumothorax, bronchopulmonary dysplasia, reactive airway disease
• **GI:** Volvulus, bowel ischemia, perforation, obstruction, late onset NEC (premature infants >2 weeks old), appendicitis

*Peds Top Tips: Sudden onset bilious emesis in a previously healthy neonate (most commonly <1 month old) is volvulus until proven otherwise and is a surgical emergency.

References: 8, 9
List of imaging studies

1. Chest Radiograph
2. Abdominal Radiograph
3. Chest Radiograph Post-Intubation
4. Chest Radiograph Adjusted ETT
5. Abdominal Radiograph Post-Ex-lap
Imaging studies from PACS 1

AP Chest X-Ray (Supine, Portable)
Imaging discussion 1

- Was this study appropriate?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Procedure</th>
<th>Adult RRL</th>
<th>Peds RRL</th>
<th>Appropriateness Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory illness, acute, abnormal exam, initial exam</td>
<td>Radiography chest</td>
<td>&lt;0.1 mSv</td>
<td>&lt;0.03 mSv [ped]</td>
<td>Usually appropriate</td>
</tr>
<tr>
<td>US chest</td>
<td></td>
<td>0 mSv</td>
<td>0 mSv [ped]</td>
<td>May be appropriate</td>
</tr>
<tr>
<td>CT chest without IV contrast</td>
<td></td>
<td>1-10 mSv</td>
<td>3-10 mSv [ped]</td>
<td>Usually not appropriate</td>
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<tr>
<td>CT chest with IV contrast</td>
<td></td>
<td>1-10 mSv</td>
<td>3-10 mSv [ped]</td>
<td>Usually not appropriate</td>
</tr>
<tr>
<td>CT chest without and with IV contrast</td>
<td></td>
<td>1-10 mSv</td>
<td>3-10 mSv [ped]</td>
<td>Usually not appropriate</td>
</tr>
<tr>
<td>MRI chest without IV contrast</td>
<td></td>
<td>0 mSv</td>
<td>0 mSv [ped]</td>
<td>Usually not appropriate</td>
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<tr>
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<td></td>
<td>0 mSv</td>
<td>0 mSv [ped]</td>
<td>Usually not appropriate</td>
</tr>
</tbody>
</table>

Reference: 1
Imaging discussion 1

AP Chest X-Ray (Supine, Portable)

T – Technique: Includes entire lung field, good exposure, head is rotated to the right
A – Airways: Clear trachea, carina, and right and left main stem bronchi, no apparent foreign bodies
B – Breathing (lung and pleura): Costophrenic angles are clear and well visualized, clear lung fields - No pleural effusion or pneumothorax
C – Circulation: Normal heart size, Mediastinal width consistent with thymic shadow
D – Disability: No fractures
E – Everything else: Intraperitoneal free air, large dilated bowel loops, gastrostomy tube present over stomach
*Telemetry lead

Three most common signs of Pneumoperitoneum:
1. Sub-diaphragmatic air
2. Air on both sides of the bowel wall
3. Visualization of the falciform ligament

Reference: 5
Imaging studies from PACS 2

Supine Abdominal X-Ray
Imaging discussion 2

- Was this study appropriate?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Procedure</th>
<th>Adult RRL</th>
<th>Peds RRL [ped]</th>
<th>Appropriateness Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abd pain, acute, nonlocalized, fever, initial exam</td>
<td>CT abdomen and pelvis with IV contrast</td>
<td>1-10 mSv</td>
<td>3-10 mSv [ped]</td>
<td>Usually appropriate</td>
</tr>
<tr>
<td></td>
<td>US abdomen</td>
<td>0 mSv</td>
<td>0 mSv [ped]</td>
<td>May be appropriate</td>
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<tr>
<td></td>
<td>MRI abdomen and pelvis without and with IV contrast</td>
<td>0 mSv</td>
<td>0 mSv [ped]</td>
<td>May be appropriate</td>
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<td>MRI abdomen and pelvis without IV contrast</td>
<td>0 mSv</td>
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<td>CT abdomen and pelvis without IV contrast</td>
<td>1-10 mSv</td>
<td>3-10 mSv [ped]</td>
<td>May be appropriate</td>
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<td></td>
<td>Radiography abdomen</td>
<td>0.1-1mSv</td>
<td>0.03-0.3 mSv [ped]</td>
<td>May be appropriate</td>
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<tr>
<td></td>
<td>CT abdomen and pelvis without and with IV contrast</td>
<td>10-30 mSv</td>
<td>10-30 mSv [ped]</td>
<td>May be appropriate</td>
</tr>
<tr>
<td></td>
<td>Nuclear medicine scan gallbladder</td>
<td>0.1-1mSv</td>
<td>Null</td>
<td>Usually not appropriate</td>
</tr>
<tr>
<td></td>
<td>FDG-PET/CT skull base to mid-thigh</td>
<td>10-30 mSv</td>
<td>3-10 mSv [ped]</td>
<td>Usually not appropriate</td>
</tr>
</tbody>
</table>

Reference: 1
Imaging discussion 2

- **Rigler Sign**
  - “Double Wall Sign”, when air is present on both sides of the bowel wall causing a very distinct and crisp visualization of the bowel wall
  - Second most common sign seen in pneumoperitoneum after sub-diaphragmatic air
  - Beware Pseudo-Rigler Sign

- **Normal Air Pattern Abdominal X-ray**

**Supine Abdominal X-Ray**

- **T** – Technique: Good exposure, lower lung fields not visualized
- **A** – Air: multiple dilated air filled bowel loops, intraperitoneal air, +Rigler sign, no pneumatosis intestinalis
- **B** – Bowel: Dilated small and large bowel, air present on both sides of bowel wall
- **D** – Densities: No fractures, no abnormal calcifications
- **O** – Organs: difficult to visualize other structures given dilated bowel loops, lower lung fields not visualized
- **E** – External Objects: telemetry lines, overlying G-tube

Reference: 2, 5
Imaging discussion 2

Left Lateral Decubitus Position
- May assist in visualizing small volume pneumoperitoneum.

Falciform Ligament Sign
- Solid white arrows, air outlines the ligament causing it to be distinctly seen. Usually seen in larger volume pneumoperitoneum and will often have additional signs such as Rigler present.

Reference: 5, 7
Imaging studies from PACS 3 (Post intubation)

AP Chest X-Ray (Supine, Portable)
Imaging discussion 3 (Post Intubation)

AP Chest X-Ray (Supine, Portable)

T – Technique: Includes entire lung field, good exposure
A – Airways: ETT traverses trachea terminating in right mainstem bronchus
B – Breathing (lung and pleura): Complete opacification of the left lung and reduced left hemithorax volume, right lung is clear with sharp costophrenic angle
C – Circulation: left cardimediastinal silhouette obscured
D – Disability: No fractures
E – Everything else: Intraperitoneal free air, large dilated bowel loops, gastrostomy tube present over stomach, telemetry wires
Imaging studies from PACS 4 (ETT retracted ~1 cm)

AP Chest X-Ray (Supine, Portable)
Imaging discussion 4 (ETT retracted ~1 cm)

**AP Chest X-Ray (Supine, Portable)**

T – Technique: Includes entire lung field, good exposure

A – Airways: ETT traverses trachea terminating near the carina

B – Breathing (lung and pleura): Interval improvement in left lung opacification with residual biapical opacifications, bilateral, clear sharp costophrenic angles

C – Circulation: normal cardimediastinal silhouette

D – Disability: No fractures

E – Everything else: Significant interval improvement in intraperitoneal free air and dilated bowel, gastrostomy tube present over stomach
Imaging discussion 4 (ETT retracted ~1 cm)

- Prior and newest films
Patient treatment or outcome

• Emergent Exploratory laparotomy 7/16
  • Feculent Peritonitis with perforated, necrotic distal ileum and cecum
  • Mesentery thrombosed to these segments of bowel
  • 90 cm of small bowel and cecum resected
• Broad Spectrum Antimicrobials: Vanc, Cefepime, Metronidazole
• Complicated by DIC and multi-organ failure
• Repeat Exploratory Laparotomy 7/20
  • 10 cm resection
• Currently doing well extubated on HFNC, ileostomy formation 8/1
Imaging studies from PACS 5 (Post-Emergent Ex-lap)

Supine Abdominal X-Ray
Imaging discussion 5 (Post- Emergent Ex-lap)

Supine Abdominal X-Ray

T – Technique: Good exposure, lower lung fields visualized

A – Air: nonobstructive bowel gas pattern, gastric bubble, significant interval improvement in extraluminal air (negative sub-diaphragmatic air, - Rigler sign)

B – Bowel: Interval improvement in dilated bowel

D – Densities: No fractures, no abnormal calcifications

O – Organs: clear costophrenic angles with no opacities noted

E – External Objects: telemetry lines, G-tube overlying mid-abdomen, surgical wound vac tube over mid abdomen, rectal temperature probe, left femoral venous catheter terminating at approximately the level of L4
Diagnosis of pneumoperitoneum

• Sensitivity and Specificity of different modalities:
  • Chest Radiograph (most common): Sensitivity 79%, Specificity 64%
  • Ultrasound: Sensitivity 95.5%, Specificity 81.8%
  • Low Dose CT: Sensitivity 95%, Specificity 100%

• Cost and Radiation Exposure of different modalities (Pediatric):
  • Chest Radiograph: <0.03 mSv, ~$175
  • Abdominal Radiograph: 0.3 mSv, ~$175
  • Ultrasound: 0 mSv, ~$374
  • CT Abdomen/Pelvis w/ contrast: 3-10 mSv, ~$1,160

• Our Patient:
  • 40 Chest X-rays since admission, 1.2 mSv, ~$7,000
  • 5 Abdominal X-rays since admission, 1.4 mSv, ~$875

Reference: 3, 4, 6, 8
UNC Top Three

• Radiographic findings concerning from ruptured viscus/pneumoperitoneum include Sub-diaphragmatic air, Rigler sign, and Falciform ligament sign.
  • Consider left lateral decubitus position for better visualization of small intraperitoneal air volume.

• Extra-luminal air that cannot be otherwise explained (recent abdominal surgery) is a surgical emergency.

• Consider using ultrasound in the diagnosis of pneumoperitoneum in the pediatric population.
References


